Structure and Function of Muscle

Skeletal Muscle Structure

- Skeletal muscle is composed of bundles of muscle fibers (cells), each containing myofibrils made up of repeating units called sarcomeres.
- The sarcomere is the fundamental contractile unit, consisting of actin (thin) and myosin (thick) filaments whose interaction produces muscle contraction[1].
- Muscle fibers are surrounded by connective tissue layers: endomysium (around each fiber), perimysium (around bundles/fascicles), and epimysium (around the entire muscle)[1].

Muscle Function

- Muscles produce force and create movement by contracting in response to neural stimulation.
- Muscle contraction occurs when the nervous system sends a signal, triggering the sliding of actin and myosin filaments within the sarcomere, shortening the muscle and generating force[1].
- The type of muscle fiber (slow-twitch vs. fast-twitch) influences force production and fatigue resistance[1].

Types of Connective Tissue

Major Types

- **Tendons:** Connect muscle to bone, transmitting the force generated by muscle contraction to produce movement.
- **Ligaments:** Connect bone to bone, stabilizing joints.
- **Fascia:** Sheets of connective tissue that envelop muscles, groups of muscles, blood vessels, and nerves, binding some structures together while permitting others to slide smoothly over each other.

- **Epimysium, Perimysium, Endomysium:** Connective tissue layers within muscle that provide structural support, aid in force transmission, and house blood vessels and nerves[1].

Hypertrophy and Muscle Adaptations to Strength Training

Hypertrophy

- Hypertrophy is the enlargement of muscle fibers due to an increase in the amount of structural proteins (such as actin and myosin) within each fiber, resulting in increased muscle diameter[2][3].
- Resistance training stimulates hypertrophy by causing microscopic damage to muscle fibers, which then repair and grow stronger and larger[2][3].
- Muscle hypertrophy does not involve an increase in the number of muscle cells, but rather an increase in the size of existing cells[2][3].

Other Adaptations

- Resistance training can also cause changes in muscle fiber type composition and improve the metabolic properties of muscle, enhancing endurance and strength[1].

Nervous System’s Role in Building Muscular Strength

Neural Adaptations

- Initial strength gains from resistance training are primarily due to neural adaptations rather than muscle hypertrophy[4][5][6][7].
- The nervous system becomes more efficient at:
    - **Recruiting more motor units:** More muscle fibers are activated during a contraction, especially the larger, high-force-producing fast-twitch fibers[4][6][7].
    - **Increasing firing rate:** Motor neurons send signals more rapidly, resulting in stronger, more forceful contractions[8][7].
    - **Improving intermuscular coordination:** Different muscles work together more effectively, optimizing movement patterns and force production[7][9].
    - **Reducing neural inhibition:** The nervous system becomes less restrictive, allowing greater force output by reducing the action of protective reflexes like those from the Golgi tendon organs[7].

Neuroplasticity

- Strength training also enhances neuroplasticity, the brain's ability to form new neural connections, which improves skill acquisition and coordination[6].

Summary Table: Muscle vs. Neural Adaptations

Adaptation Type	Mechanism	Time Course	Effect on Strength
Neural	Motor unit recruitment, firing rate, coordination, reduced inhibition	Rapid (weeks)	Major initial gains
Hypertrophy	Increased protein synthesis, fiber size	Slower (months)	Sustained gains

Key Points

- Muscle structure and function are tightly linked to their ability to produce force and adapt to training[1].
- Connective tissues provide support, transmit force, and protect muscle structures[1].
- Strength gains from resistance training are initially driven by neural adaptations, with hypertrophy contributing more over time[4][5][6][7][2][3].
- The nervous system's efficiency in activating and coordinating muscles is crucial for building strength[4][6][7][9].

⁂

1. http://downloads.lww.com/wolterskluwer_vitalstream_com/sample-content/9781451193190_Kraemer/samples/Kraemer_Chap04.pdf
2. https://courses.lumenlearning.com/suny-fitness/chapter/exercise-and-muscle-performance/
3. https://pressbooks-dev.oer.hawaii.edu/anatomyandphysiology/chapter/exercise-and-muscle-performance/
4. https://fitness.edu.au/the-fitness-zone/the-role-of-the-nervous-system-in-strength-training/
5. https://pubmed.ncbi.nlm.nih.gov/3057313/

6. https://acthealth.org/how-strength-training-bolsters-your-nervous-system/

7. https://georgiachiropracticneurologycenter.com/harnessing-neurology-for-strength/

8. https://pmc.ncbi.nlm.nih.gov/articles/PMC6441901/

9. https://omassaget.com/the-nervous-system-and-athletic-performance-enhancing-neuromuscular-coordination/